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Patentanmeldung Nr. Patent application No. Demande de brevet n°

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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R C van Dijk

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Apparatus and method for navigating an instrument through a vascular structure

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Apparatus and method for navigating an instrument through a vascular structure

The invention relates to an apparatus and method for navigating an instrument through a vascular structure of a patient's body volume, comprising a table for supporting the patient and at least a first C-arm having a X-ray source and an X-ray detector, such as an image intensifier or a flat panel X-ray detector for acquiring a first series of 2D-images of the instrument whilst maneuvering through said vascular structure, and further comprising a processing unit for the images which unit connects to a memory device, whereby the memory device holds pre-determined 3D-images of the patient's vascular structure, and the processing unit processes the 2D-images of the instrument and the 3D-images of the vascular structure so as to provide merged 3D-images of the instrument maneuvering through said vascular structure.

Such an apparatus and method are known from US-B-6 351 513.

In the known apparatus and method 3D-images of a patient's vascular structure are obtained by 3D-angiography, magnetic resonance imaging or computer tomography imaging. These 3D-images are of comparatively high resolution and quality.

To alleviate navigational difficulties that the radiologist experiences when a medical instrument such as a catheter is pushed through said vascular structure to a region of interest, US-B-6 351 513 teaches to apply real time 2D imaging of the instrument whilst maneuvering through the vascular structure and merging the 2D-image of the instrument with the predetermined 3D-images of the vascular structure. Since the catheter is moving through a vessel the catheter must according to US-B-6 351 513 actually lie in 3D space, somewhere on a "sheaf" which is a surface formed by taking a line (a catheter) and keep sweeping along the length of the catheter. This generates a surface and the catheter can be anywhere on that surface. Since we know that the catheter is moving through the vessel which is a 3D structure, the intersection of this surface with the pre-stored 3D reconstruction data, gives the location of the catheter. US-B-6 351 513 teaches: if the 3D reconstruction of the vessels is known (i.e. from the 3D-angiography reconstruction) the position of the catheter is also known since it is confined within the reconstructed vessels.

Several problems attach to the method and apparatus according to US-B-6 351 513. As a first problem the known art does not take into account that the position of the C-

arm is not always calibrated, causing that inaccuracies occur and correspondence is lacking between the priorly acquired 3D-images of the vascular structure and the later acquired 2D-images of the instrument.

A second problem is that during imaging the patient may intentionally or unintentionally move. Even movement due to beating of the heart and breathing may give rise to unacceptable inaccuracies.

A third problem is that the radiologist may elect to move the table on which the patient is laying in an effort to improve his view at the instrument during maneuvering.

All said problems may result in discrepancies in the merged images of the instrument and the vascular structure making same unreliable.

With the apparatus and method according to the invention it is aimed to reduce or circumvent these problems.

To this end the apparatus according to the invention is characterized in that the processing unit carries out a 2D-3D registration to relate the coordinates of the 2D-images of the instrument to the coordinates of the 3D-images of the vascular structure prior to providing the merged 3D-images of the instrument and the vascular structure. It is to be noted that at least in part the 3D-images of the vascular structure may also be obtained during the intervention with the instrument.

A preferred embodiment of the apparatus according to the invention is characterized it comprises a second C-arm with a X-ray source and an image intensifier for acquiring a second series of 2D-images simultaneously with the first series of 2D-images, and that the processing unit carries out the 2D-3D registration on both the first series and the second series of 2D-images of the instrument, whereafter the processing unit derives a 3D-image of the instrument based on said first and second series of 2D-images and said 3D-image of the instrument is merged with the 3D-images of the vascular structure. This embodiment provides the advantage that the 3D-image of the instrument and in particular its location within the patient's body volume can be established independently from the priorly established 3D-image of the patient's vascular structure. This results in higher accuracy of the instrument's actual positioning in the patient's body.

Consistent with the above the method according to the invention is characterized in that the 2D-images of the instrument are registered with the 3D-images of the vascular structure prior to providing the merged 3D-images of the instrument and the vascular structure, and that in a preferred embodiment a second series of 2D-images is acquired simultaneously with the first series of 2D-images of the instrument but from a

different angle, whereby both the first series and the second series of 2D-images of the instrument are registered with the 3D-images of the vascular structure followed by deriving from the first and second series of 2D-images a series of 3D-images of the instrument, and that the 3D-images of the instrument are merged with the 3D-images of the vascular structure.

The invention is further embodied in software for a computer which is characterized by coding that is arranged for implementing the just mentioned method. The invention is also embodied in a data carrier comprising such software.

The invention will hereafter be further elucidated with reference to a non-limiting example of the apparatus and method according to the invention and with reference to the drawing.

In the drawing

Figure 1 shows schematically the apparatus according to the invention.

Figure 2 shows schematically the acquisition of a 2D-image with the aid of the apparatus according to figure 1.

Figure 3 schematically shows the merger of a 3D-image from the instrument and a predetermined 3D-image of a patient's vascular structure.

Figures 4, 5, 6 and 7 show a series of real time 3D-images of an instrument maneuvering through the vascular structure.

With reference first to figure 1 an apparatus 1 is shown for navigating an instrument through a vascular structure of a body volume of a patient 2. The apparatus 1 comprises a table 3 for supporting the patient 2 and in the shown preferred embodiment it comprises a first C-arm 4 with a X-ray source 5 and an image intensifier 6 for acquiring a first series of 2D-images. It further comprises a second C-arm 7 having a X-ray source 8 and an image intensifier 9 for acquiring a second series of 2D-images. Both image intensifiers are connected with a processing unit 10 (a computer) which connects to a memory device 11 and a display unit 12.

Initially in a manner well known in the art 3D-images of the patient's 2 vascular structure are acquired and stored in the memory device 11.

When a medical instrument such as a guide wire, a catheter, a stent or otherwise is maneuvered through the vascular structure of the patient 2 at least one of the C-arms 4, 7 but preferably both arms are used to acquire 2D-images of the instrument. For one C-arm 4 or 7 this is schematically shown in figure 2 indicating with 'F' the X-ray source, the patient's body volume shown in the middle whereby the patient's vascular structure is recognizable, and below the patient's body volume a detector for acquiring a 2D-image of the body volume under examination. When the instrument is maneuvered through the vascular structure the X-ray source operates in real time however on a low energy level, which suffices to provide images of the medical instrument.

Figure 3 relates to biplane imaging of the instrument making use of both C-arms 4 and 7. The middle of the figure shows schematically the vascular structure of the patient in the form of a 3D-image, which is acquired prior to navigating the instrument through the vascular structure.

Making use of both C-arms 4 and 7 a first series of 2D-images of the instrument and a second series of 2D-images of the instrument are acquired simultaneously which is represented by pictures A and B respectively. Picture A represents one image of a first series of images by using X-ray source Fa, picture B represents one image of the second series of images making use of X-ray source Fb. Both the first series and the second series of 2D-images of the instrument are processed by the processing unit 10 to carry out a 2D/3D registration to relate the coordinates of the 2D-images of the instrument, to the coordinates of the 3D-image of the vascular structure. This applies to both the first series of 2D-images and the second series of 2D-images of the instrument. Figure 3 symbolizes that thereafter the two series of 2D-images, which are taken from a different angle, are combined and construed into a 3D representation of the instrument, following which the 3D-image of the instrument is merged with the 3D-image of the vascular structure.

By executing the method and operating the apparatus according to the invention in real time, a series of 3D-images is acquired as shown in figures 4 to 7.

Figure 4 shows the tip of a guide wire at the entrance portion of the vascular structure of an patient's body volume under examination. Figure 5 shows same when the guide wire has progressed a little and figures 6 and 7 show same in even further progressed positions.

It is emphasized that the invention can advantageously use any known form of 2D/3D registration to relate the coordinates of the 2D-images of the instrument to the coordinates of the 3D-images of the vascular structure. For this purpose one could select one

of the methods described in the article "A Comparison of Similarity Measures for use in 2D/3D Image Registration" by Graeme P. Penney et al., IEEE Transactions On Medical Imaging, Vol. 17, No. 4, August 1998, pages 586 to 595.

CLAIMS:

1. Apparatus for navigating an instrument through a vascular structure of a patient's body volume, comprising a table for supporting the patient and at least a first C-arm having a X-ray source and an X-ray detector for acquiring a first series of 2D-images of the instrument whilst maneuvering through said vascular structure, and further comprising a processing unit for the images which unit connects to a memory device, whereby the memory device holds pre-determined 3D-images of the patient's vascular structure, and the processing unit processes the 2D-images of the instrument and the 3D-images of the vascular structure so as to provide merged 3D-images of the instrument maneuvering through said vascular structure, characterized in that, the processing unit carries out a 2D-3D registration to relate the coordinates of the 2D-images of the instrument to the coordinates of the 3D-images of the vascular structure prior to providing the merged 3D-images of the instrument and the vascular structure.

2. Apparatus according to claim 1, characterized in that, it comprises a second C-arm with a X-ray source and an X-ray detector for acquiring a second series of 2D-images simultaneously with the first series of 2D-images, and that the processing unit carries out the 2D-3D registration on both the first series and the second series of 2D-images of the instrument, whereafter the processing unit derives a 3D-image of the instrument based on said first and second series of 2D-images and said 3D-image of the instrument is merged with the 3D-images of the vascular structure.

3. Method for navigating an instrument through a vascular structure of a patient's body volume comprising the steps of

- acquiring 3D-images of the patient's vascular structure
- acquiring a first series of 2D-images of the instrument whilst maneuvering through the vascular structure
- processing the 2D-images of the instrument and the 3D-images of the vascular structure for providing merged 3D-images of the instrument maneuvering through the vascular structure

characterized in that, the 2D-images of the instrument are registered with the 3D-images of the vascular structure prior to providing the merged 3D-images of the instrument and the vascular structure.

4. Method according to claim 1, characterized in that, a second series of 2D-images is acquired simultaneously with the first series of 2D-images of the instrument but from a different angle, that both the first series and the second series of 2D-images of the instrument are registered with the 3D-images of the vascular structure followed by deriving from the first and second series of 2D-images a series of 3D-images of the instrument, and that the 3D-images of the instrument are merged with the 3D-images of the vascular structure.

5. Software for a computer characterized by coding for implementing the method according to claim 3 or 4.

6. Data carrier comprising software according to claim 5.

ABSTRACT:

Apparatus for navigating an instrument through a vascular structure of a patient's body volume, comprising a table for supporting the patient and at least a first C-arm having a X-ray source and an image intensifier for acquiring a first series of 2D-images of the instrument whilst maneuvering through said vascular structure, and further comprising a processing unit for the images which unit connects to a memory device, whereby the memory device holds pre-determined 3D-images of the patient's vascular structure, and the processing unit processes the 2D-images of the instrument and the 3D-images of the vascular structure so as to provide merged 3D-images of the instrument maneuvering through said vascular structure. The processing unit carries out a 2D-3D-registration to relate the coordinates of the 2D-images of the instrument to the coordinates of the 3D-images of the vascular structure prior to providing the merged 3D-images of the instrument and the vascular structure.

Fig. 3

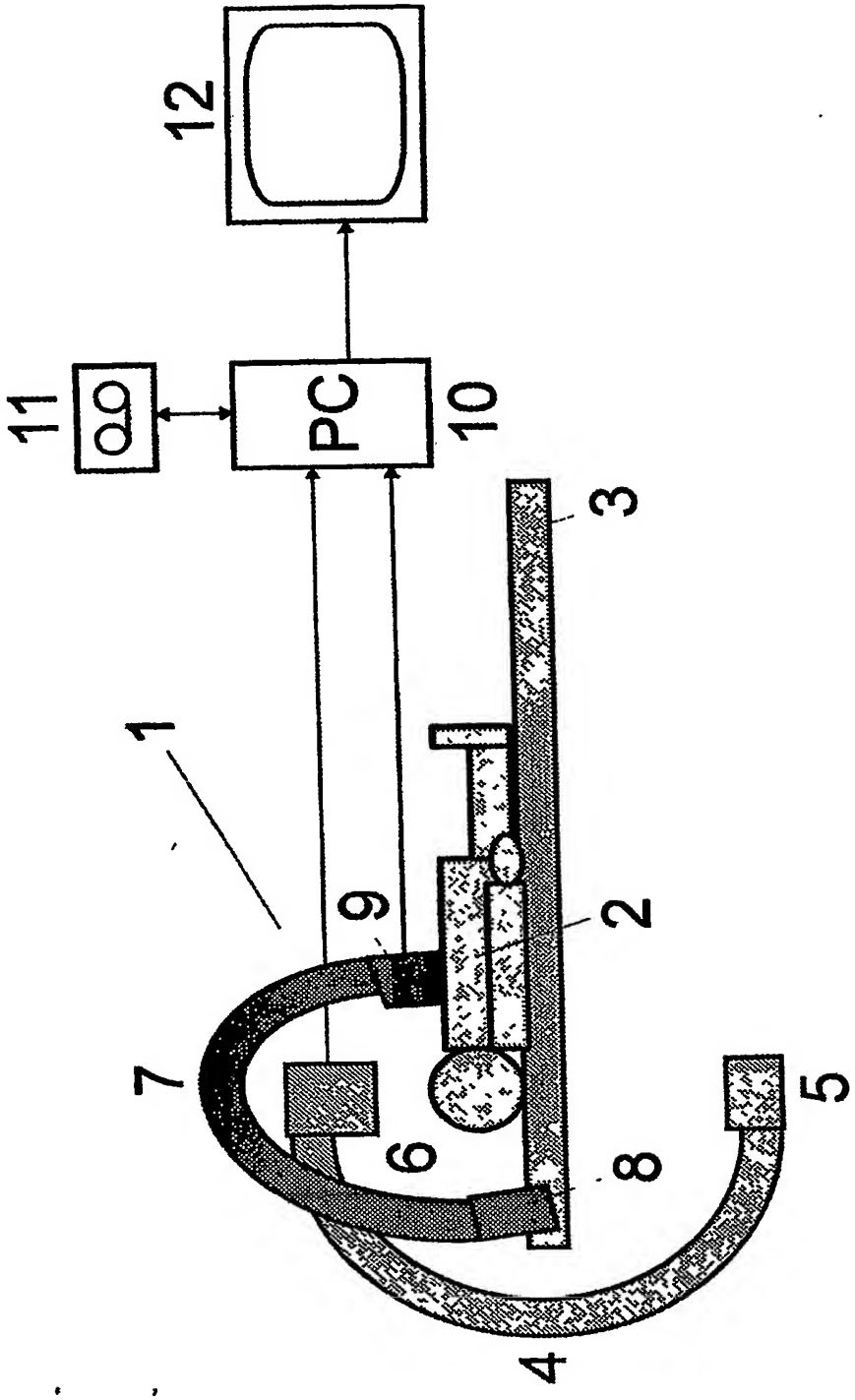

FIG.1

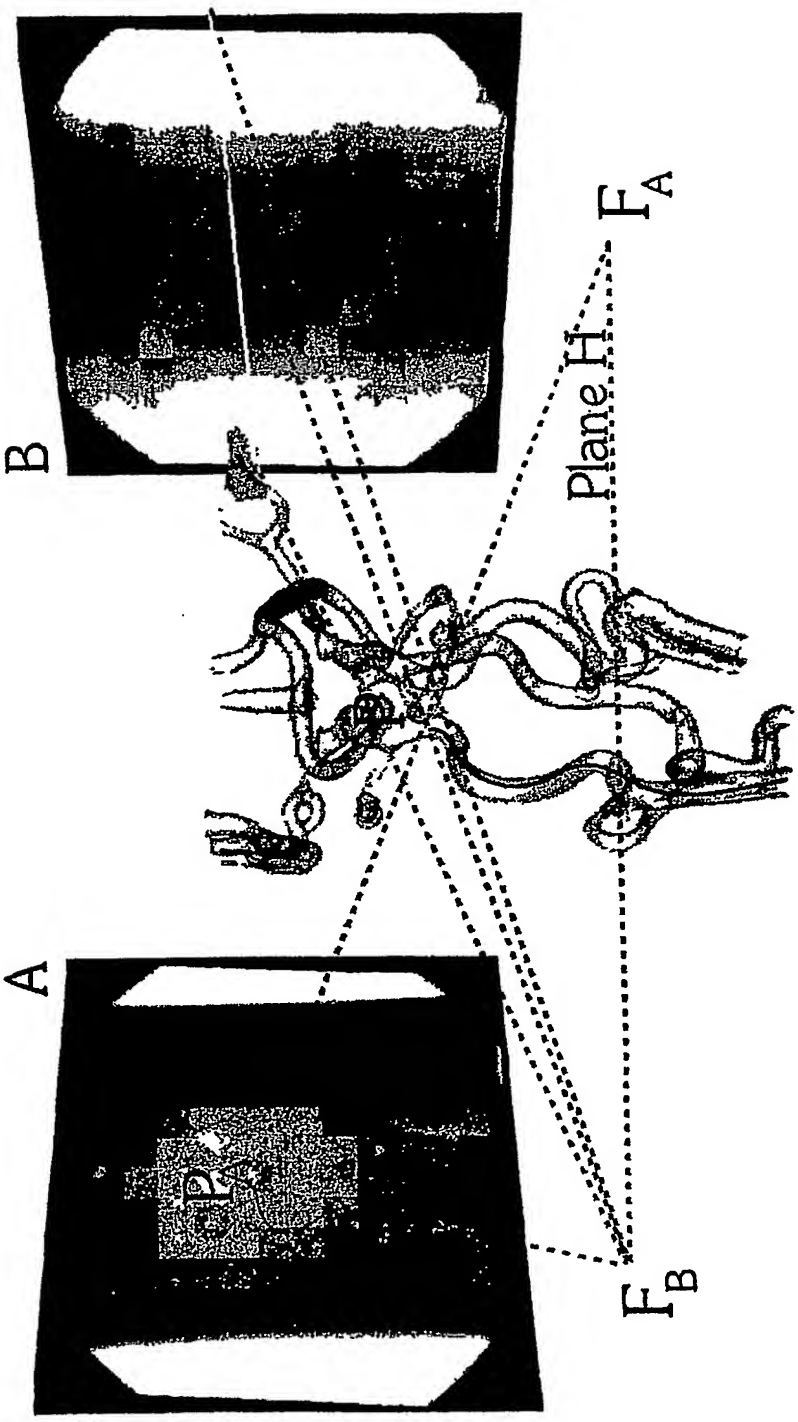

FIG.3

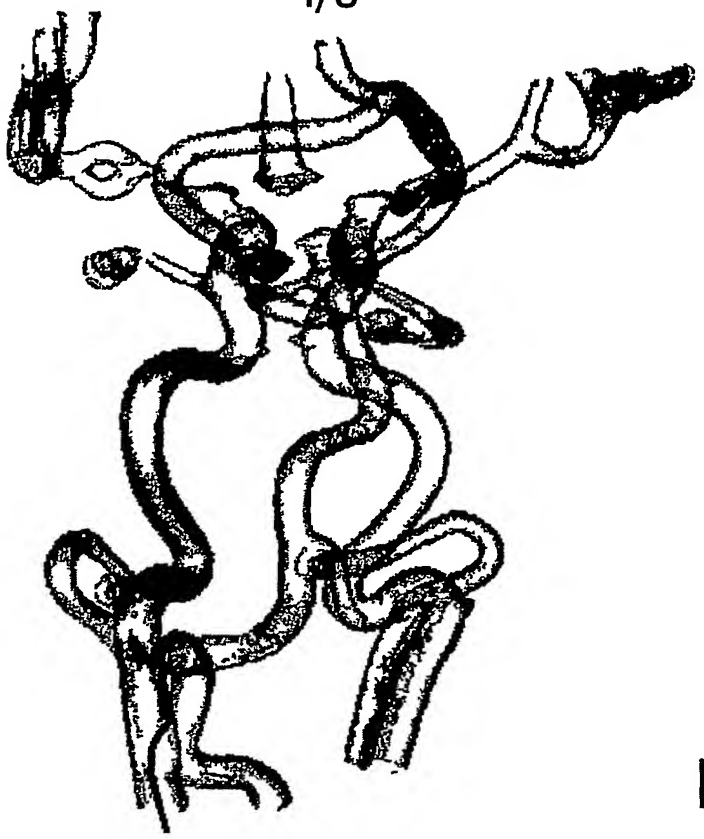

FIG.4

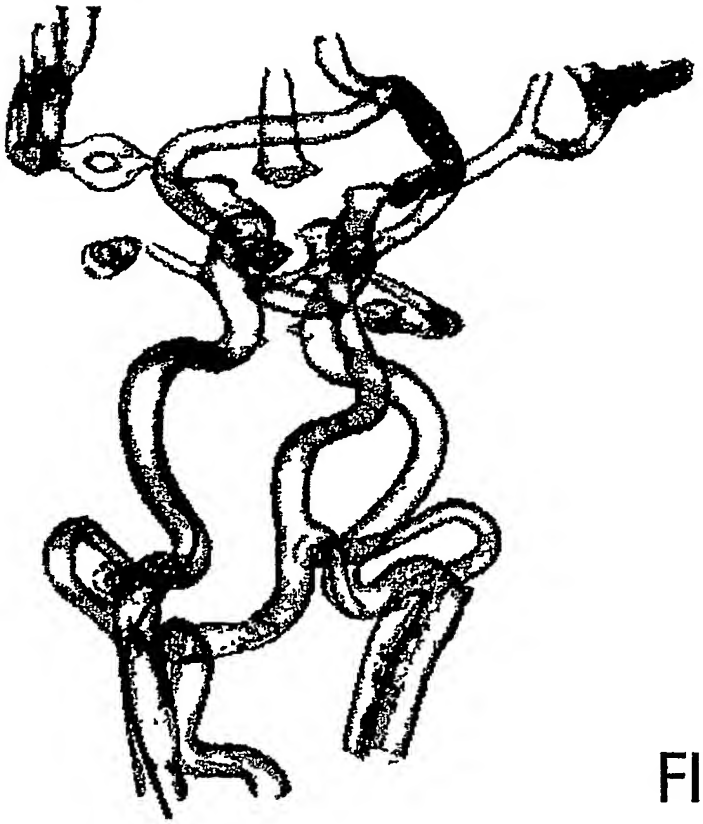

FIG.5

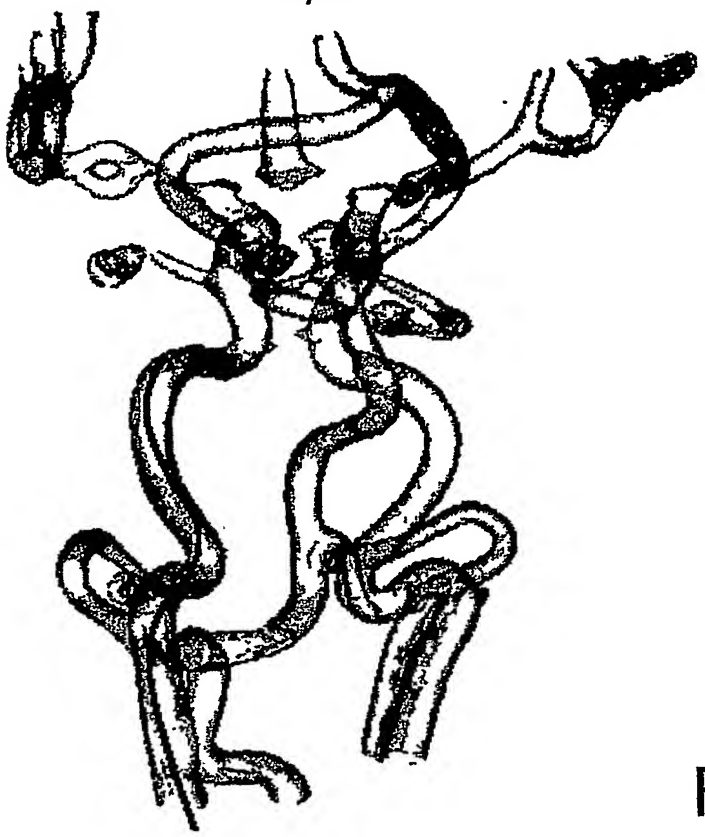

FIG.6

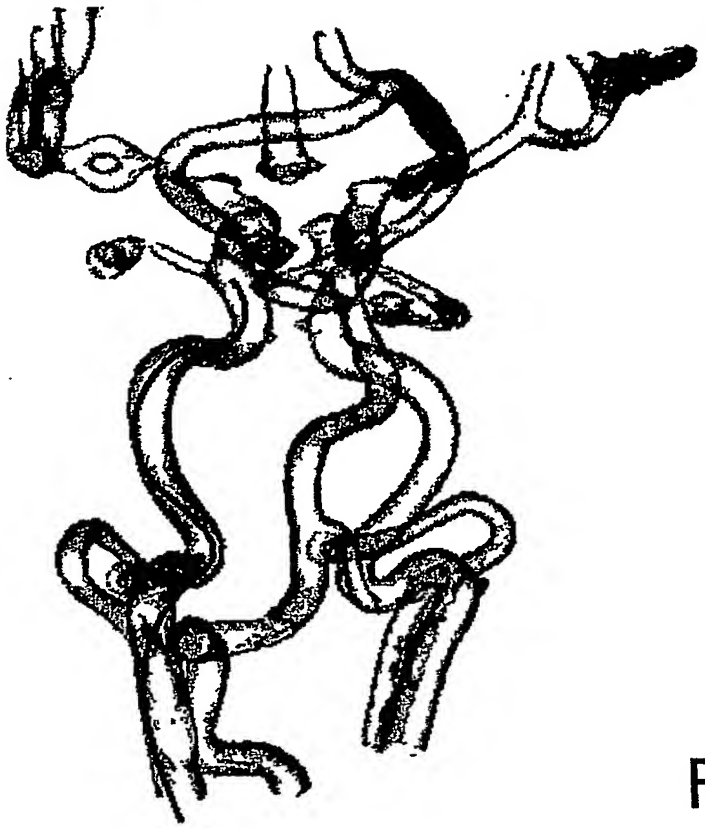

FIG.7